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Title: Adhesion, microstructure and electrical resistance of sputtered Cu films on alumina substrates

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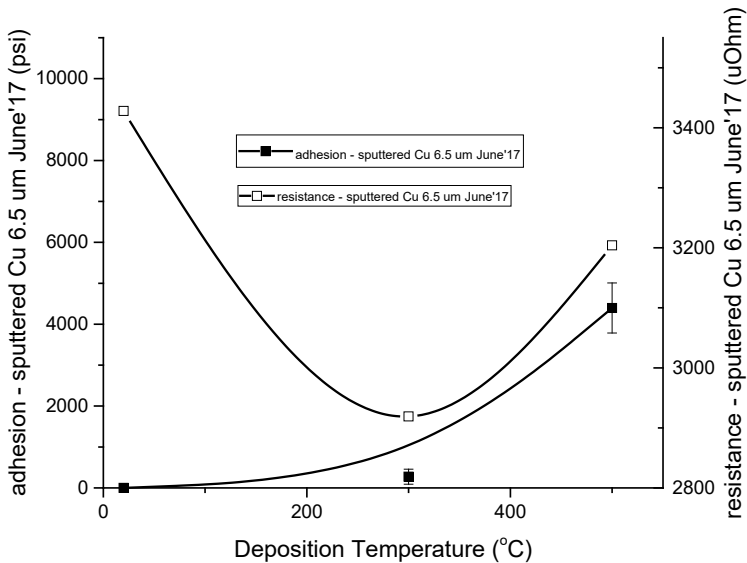
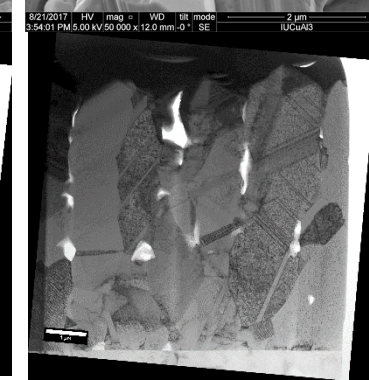
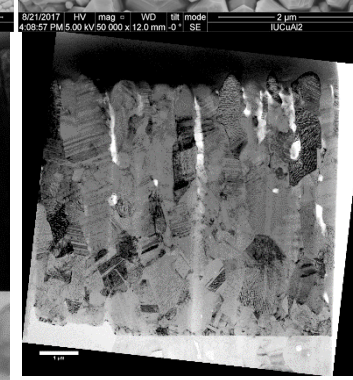
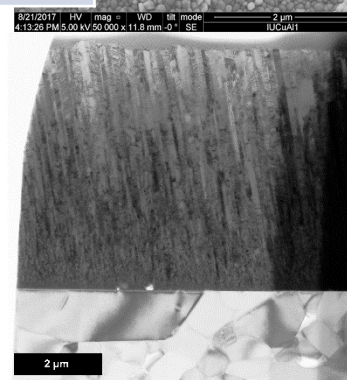
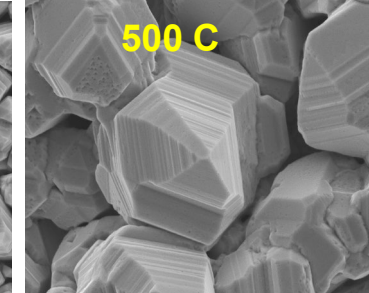
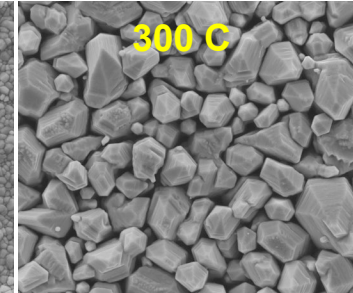
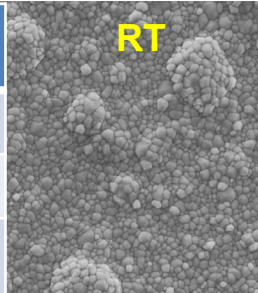
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Adhesion, microstructure and electrical resistance of sputtered Cu films on alumina substrates

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Run	Max. Adhesion Strength (psi)	R $\mu\Omega$, Keysight	Thickness $\mu''/\mu\text{m}$ Oxford	Thickness μm QCM	Thickness μm TEM
6-8-17 Cu RT	0, 0 (delaminated during curing)	3428	132.5 / 3.35	6.7	5.48 (no porosity)
6-9-17 Cu 300C	405, 144 (274.5 \pm 184.5)	2919	158.1 / 4.1	6.9	6.45 (porosity 1.4%)
6-13-17 Cu 500C	4828, 3964 (4396 \pm 611)	3204	144.1 / 3.66	6.6	6.42 (porosity 3.5%)



- Cu film thickness is grossly underestimated by using Oxford instrument (electrical resistance)
- Cu film thickness is in good agreement between QCM and TEM at 300 C and 500 C, discrepancy observed at RT is likely because QCM calibration was done at 500 C
- Electrical resistance depends on film thickness and microstructure (grain size, porosity, etc.)
- Adhesion is likely affected by contaminants, strain and porosity at the film/substrate interface :
 - ✓ At RT: amorphous layer (~ 4 nm, likely initial alumina surface contamination), porosity and significant strain
 - ✓ At 300°C: thin amorphous layer (< 1nm), no porosity and small strain
 - ✓ At 500°C: no amorphous layer, porosity and no strain
- Film microstructure and film/substrate interface can be controlled by deposition temperature